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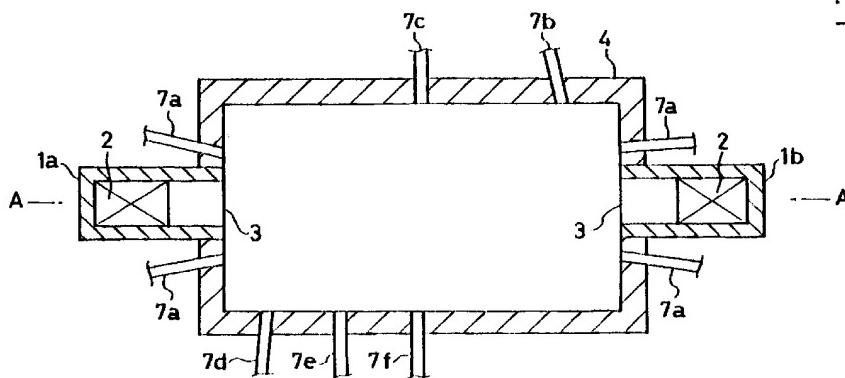
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(54) A low nitrogen oxide producing burner system and burning method

(57) A low-nitrogen-oxide-producing regenerative burner system for a combustion chamber (4) comprises at least one pair of regenerative preheaters (1a, 1b) for combustion air connected to the combustion chamber to supply preheated air directly thereinto or to receive combustion products therefrom for heat recovery and at least one fuel supply duct (7) connected to the combus-

tion chamber at a position spaced from the points at which air is delivered to the chamber. The fuel and pre-heated air are supplied separately to the chamber so that they mix within it and are diluted by combustion products so that the flame temperature is kept low and the production of nitrogen oxides is inhibited.

FIG. 1



Description

The present invention relates to an improved low nitrogen oxide producing burner system and burning method and a combustion chamber equipped with the burner system, particularly for use in high temperature industrial furnaces, usually with hydrocarbon fuels in the gaseous state.

A conventional, prior-art regenerative burner is shown in Figure 6 and comprises a pair of burner means 11 connected to a furnace 4 and each having a regenerating section 2 and a fuel supply section 13. In use, air is introduced through an air inlet section 9, as shown by the arrows in the drawing, to one of the burner means 11a where it is preheated in the regenerating section 2. Then, while rising, it is mixed with fuel injected through the fuel supply section 13a and the air-fuel mixture is subsequently injected into the furnace 4 where it continues to burn. The exhaust gas from the furnace 4 is then used for heat exchange, i.e. for heat regeneration, in the regenerating section of the other burner means 11b and subsequently exits through an exhaust section 10 thereof. The burner means 11 are used alternately for burning and exhausting at very short intervals of tens of seconds to several minutes.

This burning method, i.e., regenerative burning method, can achieve high waste-heat recovery, resulting in good fuel economy, and is also important as regards environmental protection since it also results in decreased CO₂ emissions.

Although the above, known regenerative burning method is excellent as a means of increasing waste heat recovery, it has a very great disadvantage in that the temperature of the preheated combustion air is so high that the flame temperature is raised and results in remarkably increased nitrogen oxide (NOx) emissions.

Even if known NOx decreasing techniques are applied to the above regenerative combustion method, such as staged combustion, exhaust gas recirculation or water spraying, the NOx emissions can be decreased at most by only 50 to 60%, from 500-1200 ppm (O₂ 11%) to 200-500 ppm (O₂ 11%). This does not meet the regulatory level of 180 ppm (O₂ 11%) required by the Air Pollution Control Law of Japan.

The object of the present invention is to provide a burner system and method which can achieve low NOx emissions even when the combustion air is heated to relatively high temperatures and which, at least in a preferred embodiment, can result in stable burning even at variable furnace temperatures.

Accordingly, in one aspect, the present invention provides a low-nitrogen-oxide-producing regenerative burner system for a combustion chamber comprising a pair of regenerative preheaters, or regenerators, for combustion air and a fuel supply duct, characterised in that each regenerative preheater is connectable to the combustion chamber to supply preheated air directly thereinto or to receive combustion products therefrom for recovery of heat from the combustion products and

the fuel supply duct is connectable to the combustion chamber at a position spaced from the points at which air is delivered to the chamber. Since the preheaters supply air directly into the chamber and receive exhaust from it, in use, their air-inlet sections preferably also serve as exhaust outlets.

In particular the burner system of the invention comprises a pair of regenerative preheaters, or regenerators, each having a regenerating section only within it, the fuel injection means being separate from the regenerators. The system may include more than one pair of regenerators and associated fuel supply ducts, these preferably terminating in nozzles for injecting fuel into the combustion chamber.

In a preferred embodiment of the invention, each regenerator has an air supply section connected directly to an aperture of the combustion chamber, in use, and at least one, preferably each, air supply section includes an auxiliary fuel supply duct arranged to supply fuel into the air flow and directly into the chamber for use at low furnace temperatures.

The present invention is also directed to a low-nitrogen-oxide-producing combustion system, comprising a combustion chamber, such as a furnace, and a pair of regenerative preheaters for combustion air; an air-inlet aperture to the combustion chamber associated with each preheater and at least one fuel supply duct for supplying fuel for combustion in the chamber, characterised in that each preheater is connected to the respective air-inlet aperture to supply preheated air directly into the combustion chamber or to receive combustion products directly therefrom to recover waste heat from the combustion products and the at least one fuel supply duct opens directly into the combustion chamber at a position spaced from the air-inlet apertures such that mixing of the fuel and air occurs within the combustion chamber itself in use.

The combustion system would in most cases be operated with alternating reversal of the airflow therethrough, in use, the air first being introduced through one regenerator while the other is heated by the exhaust gases and the air then being introduced into the said other regenerator while the exhaust gases exit through the first regenerator to reheat it.

The present invention also provides a method for achieving fuel-in-air combustion with low production of nitrogen oxides, comprising injecting fuel and preheated air directly into a combustion chamber at spaced apart positions and allowing the fuel and air to mix with combustion gases in the chamber to achieve burning at relatively low temperature such as to inhibit the formation of nitrogen oxides. In particular the method may be carried out with the use of the combustion system described above and can achieve good waste heat recovery with resulting fuel efficiency, while maintaining low CO₂ and NOx emissions.

The present invention further provides a low nitrogen oxide burning method using a burner comprising of one or more pairs of regenerators in which the regener-

ating section only is located inside the regenerator and the air supply and exhaust ports of the regenerators open directly into the furnace; and one or more fuel injection nozzles being provided for each of the air supply and exhaust ports, which also opens directly into the furnace at locations apart from the corresponding air supply and exhaust ports, wherein the said regenerators are alternately used for burning; the fuel may be injected steadily from each or all of the fuel injection nozzles or through selected nozzles in synchronism with the corresponding air supply.

The present invention still further provides a low nitrogen oxide producing burning method, comprising the use of a burner system consisting of one or more pairs of regenerators connected to a furnace body with their air supply and exhaust ports opening directly into the furnace; and one or more main fuel supply ducts for each of the air supply and exhaust ports also opening directly into the furnace at locations spaced from the corresponding air supply and exhaust port; and an auxiliary fuel supply duct provided in at least one and preferably each of the air supply and exhaust ports, and in which fuel is supplied through the auxiliary fuel supply duct into the furnace at lower temperatures to achieve stable combustion and the auxiliary supply ducts are closed at temperatures above a selected threshold and the main supply ducts are opened to separate the fuel supply from the air supply into the chamber. This regime ensures that stable combustion is achieved over a wide temperature range whilst also ensuring low NO_x production over this range.

Several embodiments of the invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional plan illustrating an embodiment of the present invention,

Figure 2 is a vertical section taken on the line A-A of Figure 1,

Figure 3 is a sectional plan illustrating a portion of another embodiment of the present invention,

Figure 4 is a sectional plan showing a portion of a further embodiment of the present invention,

Figure 5 is a graph showing NO_x levels produced by a regenerative burning method of the present invention compared with those produced by a prior art regenerative burner. In the graph of Figure 5, points marked 0 represent results from the prior art burning method; points marked ● represent results of the burning method of the present invention; and

* indicates the legal regulatory level, with the furnace temperature in degrees Centigrade (°C),

Figure 6 is a sectional illustration showing a known regenerative burner (prior art).

Figure 7 is a sectional illustration showing a known embodiment (prior art), and

Figure 8 is a sectional illustration showing another known embodiment (prior art).

With reference to Figures 1 to 4 of the drawings corresponding features of the three embodiments shown are indicated by the same references. Figures 1 and 2 show a furnace 4 equipped with a burner system including a pair of regenerators each designated 1. Each regenerator 1 has an inlet section 8 for the inlet of air and exhaustion of furnace gas, a regenerating section 2 for preheating the air or for recovering heat from exhausted furnace gas, and an air supply and exhaust port 3 which opens into the furnace interior.

The furnace 4 may be equipped with more than one pair of regenerators 1 and each pair can be installed in one of various different configurations, such as in series, that is with the regenerators opening into opposite walls of the furnace as shown in Figure 1, or in parallel, that is, with the regenerators arranged alongside each other and opening into the same wall of the furnace as shown in Figure 3. The regenerators' air supply and exhaust ports 3 open directly into the furnace 4.

One or more fuel injection nozzles 7 (a,b,c,d,e,f, and g) associated with each of the air supply and exhaust ports 3 opens or open directly into the furnace 4 at locations spaced from the corresponding air supply and exhaust port 3.

The positional relationships between the air supply and exhaust ports 3 and the fuel injection nozzles 7 (a,b,c,d,e,f and g), their installation angles, injection velocities and their quantitative relationship can be selected as is appropriate for a particular furnace's application or requirements. For example, one or more fuel injection nozzles 7 (a,b,c,d,e,f and g) can be associated with each air inlet port 3 and they may be located around the associated air supply and exhaust port 3 or remote therefrom.

As for the fuel injection method, each fuel injection nozzle 7 (a,b,c,d,e,f and g) can be used alone or the nozzles can be used in any combination with each other and each can be used either for injection in synchronism with one or more associated regenerators 1 which are used alternately for burning and regeneration or for steady fuel injection, irrespective of the regenerators 1 being used for burning.

Figures 1 to 3 show specific arrangements, by way of example. In Figure 1, two fuel injection nozzles indicated 7a are located near and symmetrically on opposite sides of each of two air supply and exhaust ports 3. Each nozzle 7a can be arranged to direct a fuel flow in parallel with, but more preferably angled inwardly towards, an air flow through the associated regenerator port 3.

The fuel injection nozzle 7b shows an example of a nozzle located remote from an air supply and exhaust port 3 for injection towards and downstream of an air supply and exhaust port 3. The fuel injection nozzles 7c, 7d, 7e and 7f show examples of the use of multiple fuel injection nozzles. Figure 3 shows an example in which one fuel injection nozzle 7g is located between the air supply and exhaust ports 3 of regenerators arranged in parallel.

Figure 4 shows an example in which an auxiliary fuel injection nozzle 5 is arranged axially in the regenerator 1 with its outlet coaxial with the respective air supply port 3 such that it supplies fuel directly into the furnace 4 but within the airflow through the port 3.

The regenerative burner system associated with the furnace 4 further includes control means (not shown) for regulating and controlling operational parameters such as the air temperature, air flow and direction, and fuel injection.

In use, air is introduced into the system as shown by the solid line arrow in Figure 2, through the air inlet and exhaust section 8a of one of the regenerators 1a. The air is preheated in the regenerating section 2 of the regenerator and then injected into the furnace 4. Here preheated air mixes with furnace gas and fuel injected through appropriate nozzles 7. The combination of pre-heated air, fuel and furnace gas in the appropriate mixture results in combustion. The hot combustion products (furnace gas) are exhausted from the furnace through the exhaust port 3 of the other regenerator 1b of the pair of regenerators 1 and pass into its regenerating section 2. Here some of the heat is recovered in heating the regenerating section before the combustion products exit the system through the air introducing and exhaust section 8b, as again shown by a solid line arrow in Figure 2.

The regenerative burner system can operate in a series or as a stand alone system. In the stand alone system the combustion process (or cycle) is repeated in two opposite directions alternately at short intervals of tens of seconds to several minutes. The broken arrows shown in Figure 2 show a state in which air is introduced into the system through the regenerator 1b previously used for the exhaust and the regenerator section 2 of which has been heated by the exhaust gases. Thus, preheated air only is injected into the furnace from this regenerator 1b and causes combustion of fuel supplied through appropriate fuel nozzles 7, which may differ from those used previously. The combustion products are then exhausted through the other regenerator 1a, yielding up heat in its regenerating section 2.

Within the furnace 4, the air and fuel form respective independent jets which suck large amounts of the gas filling the furnace, including inert products from previous combustion, into them before mixing together to form the combustion mixture. In other words, both the air and fuel are diluted by inert gas before they are mixed with each other to initiate burning. Hence, slow burning at a low oxygen concentration occurs in the furnace, the presence of large amounts of inert gas keeping the flame temperature relatively low and effectively inhibiting the formation of nitrogen oxides.

Reference is now made to Figure 5 which gives comparative results for a prior art furnace and a furnace of the invention. In experiments performed at a furnace temperature of 1300 °C, the NOx values produced by a prior art regenerative burner ranged between 500 and 1000 ppm (O_2 11%) while those produced by the burn-

ing method of the present invention ranged between 50 and 100 ppm (O_2 11%), achieving a NOx reduction of about 90%.

In prior art furnaces, fuel is supplied together with air into the furnace in an alternating fashion through the two regenerators but in the present invention it is possible to supply fuel steadily, without alternation. Thus, with the present invention, fuel change-over valves are not necessarily required, which is of significant advantage in that the equipment can be simplified and manufacturing and production costs can be reduced.

For a clearer understanding of the present invention, the present invention is described in comparison with known burning apparatus shown in Figure 7 and disclosed in US Patent 4,496,306.

Figure 7 shows an example of apparatus for carrying out a fuel-staged combustion method. In this method, part of the fuel and all of the combustion air are mixed in a mixing zone 12 prior to their inlet into a furnace, here indicated 6. The combustion of this fuel occurs in the presence of a very large and excessive amount of air and produces a very large and excessive air flame. The balance of the fuel is injected into the furnace around the flame through secondary nozzles 17 to be mixed with the very large air-rich flame in a downstream region. The purpose of the fuel-staged combustion method is to reduce the NOx generated at the centre of the flame by the burning of the mixture of combustion air and fresh primary fuel and to effect a complete combustion reaction with the surplus oxygen by the addition of secondary fuel, thereby finally producing a low oxygen exhaust gas composition.

The complete combustion of fuel requires large volumes of air. For example, in the case of burning natural gas, the volume of air required for complete combustion is more than ten times that of the natural gas.

In the present invention, the separate air jet, in particular, acts to suck inert gas in the furnace into the combustion mixture of air and fuel to be mixed with it before burning occurs. It will be appreciated that the amount of inert gas sucked into a jet from the furnace is proportional to the momentum of the jet; since the quantities of air required is very large, this air jet is very effective in sucking a large amount of the furnace gas into the combustion mixture and this inhibits the formation of NOx by keeping the flame temperature relatively low.

In the prior art example shown in Figure 7, all the oxygen rich air is mixed with the primary fuel for burning immediately on entry into the furnace. The burning causes the combustion gas (in the presence of the very excessive, oxygen rich flame) to expand suddenly and stall, and thus lose any force which would suck the furnace gas into the combustion mixture. Therefore, the prior art example of Figure 7 has very small amounts of the inert furnace gas in the combustion mixture as compared to the present invention and the formation of NOx starts immediately the primary fuel starts to burn in the excessive air supply hence the prior art method is very much less successful in inhibiting NOx formation.

For a further understanding of the present invention, the present invention is also described below in detail in comparison to another prior art burning apparatus shown in Figure 8 and disclosed in US Patent No. 4,842,509.

The prior art example of Figure 8 shows a typical two-stage air combustion burner. Fuel is supplied to a central zone 12 of a burner means while air is supplied through adjacent primary outlets 14. The fuel and less than the theoretically required amount of primary air are mixed here for burning to form a stable primary burning region. Secondary air holes 15 are provided around the burner means and the secondary air is mixed with the burning product formed after the first step of primary burning to complete combustion. In the burner, as shown in Figure 8, the fuel injection port and air injection outlets 14, 15 are provided in a region surrounded by a thermally-insulating refractory material so as to retain the heat from the initial combustion in this region and stabilise the flame: a high temperature is thus likely to occur. On the contrary, in the present invention, the fuel injection ports 7 (a,b,c,d,e,f and g) and the air supply and exhaust ports 3 are located so as to open directly into the furnace so that the flame is within the furnace itself. Some of the heat generated in the burning is therefore lost through radiation to surrounding areas which effectively keeps the flame temperature low, and consequently the NOx production low.

Moreover, as regards the sucking in of inert gas existing in the furnace to be mixed with the combustion mixture, the suction achieved by the air jets of the apparatus of Figure 8 is limited by the existence of the refractory wall enclosing the primary burning zone and this consequently limits the decrease in NOx production that can be achieved by the incorporation of furnace gas in the combustion mixture. On the contrary, in the present invention, since the fuel jets and the air jets enter the furnace 4 directly, there is nothing to limit the suction of the gas existing in the furnace into the jets, and the respective jets can suck large amounts of the furnace gas into the combustion mixture, achieving a remarkable reduction in NOx formation.

In the present invention, since burning is caused after large amounts of inert gas have been sucked in by, and mixed with, the jets of fuel and air, there might be a burning stability problem. For example, burning can stall when the furnace temperature is lower than the ignition temperature of the fuel. This problem is solved by using the following burning apparatus and method in the present invention.

As shown in Figure 4, an auxiliary fuel injection nozzle 5 is provided inside each of the air supply and exhaust ports 3. In this embodiment, when the furnace temperature is lower than, for example 800°C, the fuel injection nozzles 7 (a,b,c,d,e,f and g) are closed and the auxiliary fuel injection nozzle 5 only is used. Combustion and burning occurs when the fuel is mixed with the surrounding fresh air from the ports 3 and does not include the lower temperature gas in the furnace.

Therefore, a stable flame can be formed when the furnace temperature is low, and under low temperature circumstances the NOx level remain low as well.

When the furnace temperature rises higher, above 5 800 °C for example, the auxiliary fuel injection nozzle 5 can be closed and the fuel injection nozzles 7 (a,b,c,d,e,f and g) are opened so that fuel is injected through the fuel injection nozzles 7 (a,b,c,d,e,f and g) only. As a result, the burning method of the present invention as described above occurs and burning is stabilized at high temperature while the formation of NOx is inhibited by the large amounts of inert gas recirculated in the furnace.

15 Claims

1. A low-nitrogen-oxide-producing regenerative burner system for a combustion chamber (4) comprising a pair of regenerative preheaters (1a, 1b) for combustion air and a fuel supply duct (7), characterised in that each regenerative preheater is connectable to the combustion chamber to supply preheated air directly thereinto or to receive combustion products therefrom for heat recovery and the fuel supply duct (7) is connectable to the combustion chamber at a position spaced from the points at which air is delivered to the chamber.
2. A low-nitrogen-oxide-producing regenerative burner system as claimed in Claim 1, characterised in that each preheater has an air inlet section (8a, 8b) for air to be heated therein for supply to the combustion chamber, which inlet also serves as an outlet for exhausted combustion products.
3. A low-nitrogen-oxide-producing regenerative burner system according to Claim 1 or Claim 2, characterised in that at least one regenerative preheater (1) includes an air supply section for connection to the combustion chamber in which an auxiliary fuel supply duct (5) is provided.
4. A low-nitrogen-oxide-producing regenerative burner system according to Claim 3, characterised in that the auxiliary fuel supply duct (5) terminates in an injection nozzle arranged axially of the supply section so as to direct fuel substantially in the direction of the air flow therethrough and into the combustion chamber in use.
5. A low-nitrogen-oxide-producing combustion system, comprising a combustion chamber (4) and a pair of regenerative preheaters (1a, 1b) for combustion air; an air-inlet aperture (3) to the combustion chamber associated with each preheater and at least one fuel supply duct (7a, 7b, 7c, 7d, 7e, 7f, 7g) for supplying fuel for combustion in the chamber, characterised in that each preheater (1a, 1b) is connected to the respective air-inlet aperture (3) to

- supply preheated air directly into the combustion chamber (4) or to receive combustion products directly therefrom for heat recovery and the at least one fuel supply duct opens directly into the combustion chamber at a position spaced from the air-inlet apertures such that mixing of the fuel and air occurs within the combustion chamber itself in use.
- 5
6. A low-nitrogen-oxide-producing combustion system according to Claim 5, including at least two fuel supply ducts (7a, 7b, 7c, 7d, 7e, 7f, 7g), one associated with each of the regenerative preheaters, the fuel supply ducts opening into the combustion chamber at positions spaced from the air-inlet apertures (3).
- 10
7. A low-nitrogen-oxide-producing combustion system according to Claim 5 or Claim 6, characterised in that the or each said fuel supply duct opens into the combustion chamber through a nozzle such that fuel is injected into the combustion chamber in use.
- 15
8. A low-nitrogen-oxide-producing combustion system according to Claim 5, Claim 6 or Claim 7, characterised in that it includes a plurality of pairs of regenerative preheaters (1a, 1b), each preheater being connected to a respective air-inlet aperture (3) to the combustion chamber, and the air-inlet apertures being spaced from the points at which fuel supply ducts (7a, 7b, 7c, 7d, 7e, 7f, 7g) open into the chamber.
- 20
9. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 8, characterised in that the two air-inlet apertures (3) associated with the or each pair of regenerative preheaters (1a, 1b) are located on opposite sides of the combustion chamber.
- 25
10. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 8, characterised in that the two air-inlet apertures associated with the or each pair of regenerative preheaters are located in the same side of the combustion chamber.
- 30
11. A low-nitrogen-oxide-producing combustion system according to Claim 10, characterised in that the or a fuel supply duct (7g) opens into the combustion chamber between the two air inlet apertures associated with a pair of regenerative preheaters (1).
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12. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 10, characterised in that two fuel supply ducts (7a) open into the combustion chamber at positions located adjacent, and symmetrically on opposite sides of, an air-inlet aperture to the combustion chamber.
- 40
13. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 12, characterised in that it has at least one fuel-supply duct (7a) arranged to direct a fuel supply into the combustion chamber (4) at an angle to an air supply through an adjacent air-inlet aperture (3).
- 45
14. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 13, characterised in that at least one air-inlet aperture has an auxiliary fuel supply duct (5) associated therewith for injecting fuel into an airflow therethrough in use.
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15. A low-nitrogen-oxide-producing combustion system according to Claim 14, characterised in that each air inlet aperture has an associated said auxiliary fuel supply duct (5).
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16. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 15, further including a control system for controlling a flow of air through a first regenerative preheater of a pair of such preheaters into the combustion chamber, the injection of fuel into the combustion chamber for mixing with the air and combustion gases therein, and the exhaustion of the combustion products into the second regenerative preheater of the pair of preheaters to recover heat therefrom.
17. A low-nitrogen-oxide-producing combustion system according to Claim 12, characterised in that fuel is supplied to the combustion chamber continuously through the or each fuel-supply duct.
18. A low-nitrogen-oxide-producing combustion system according to any one of Claims 5 to 16, characterised in that the combustion chamber is a furnace (4).
19. A method for achieving fuel-in-air combustion with low production of nitrogen oxides, comprising injecting fuel and preheated air directly into a combustion chamber at spaced apart positions and allowing the fuel and air to mix with combustion gases in the chamber to achieve burning at relatively low temperature such as to inhibit the formation of nitrogen oxides.
20. A method according to Claim 19, characterised in that the air is preheated in a first regenerative preheater before introduction into the combustion chamber and the combustion products are exhausted through a second regenerative preheater where heat is recovered.
21. A method according to Claim 19, characterised in that it includes the step of stopping the flow of air through the first regenerative preheater and reversing the air flow with the introduction of air into the

combustion chamber through the second regenerative preheater once this has been heated to a desired temperature by exhaust combustion products, and repeating the air flow reversal cyclically while maintaining fuel injection into the combustion chamber to maintain combustion therein either by effecting a steady fuel supply at the or each fuel inlet position or by effecting fuel supply at selected fuel inlet positions in synchronism with the air flow reversal.

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22. A method for achieving stable fuel-in-air combustion with low production of nitrogen oxides, comprising injecting fuel directly into the combustion chamber in an air stream supplied directly from a preheater at relatively low temperatures, enabling the fuel and air to form a combustion mixture and to burn within the chamber, and supplying preheated air and fuel directly into the combustion chamber at spaced apart positions at relatively higher temperatures such that the fuel and air mix with combustion products in the chamber and burn, while production of nitrogen oxides is inhibited throughout the burning process.

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FIG. 1

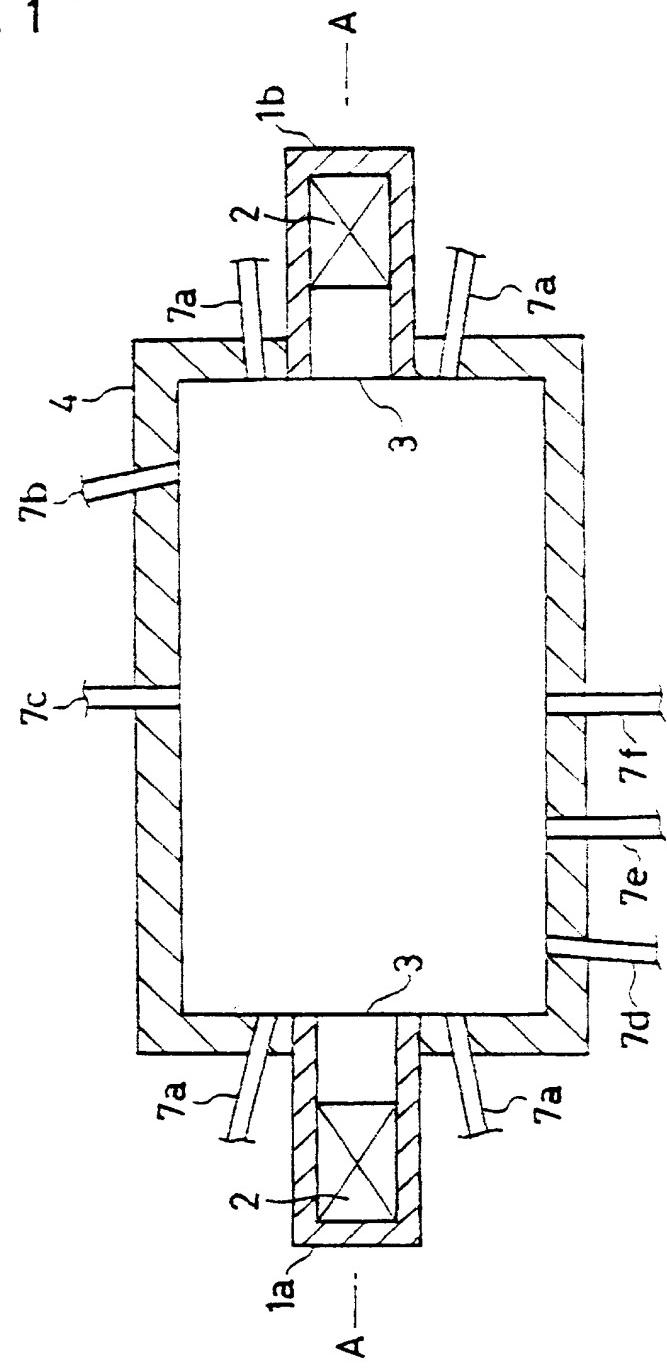


FIG. 2

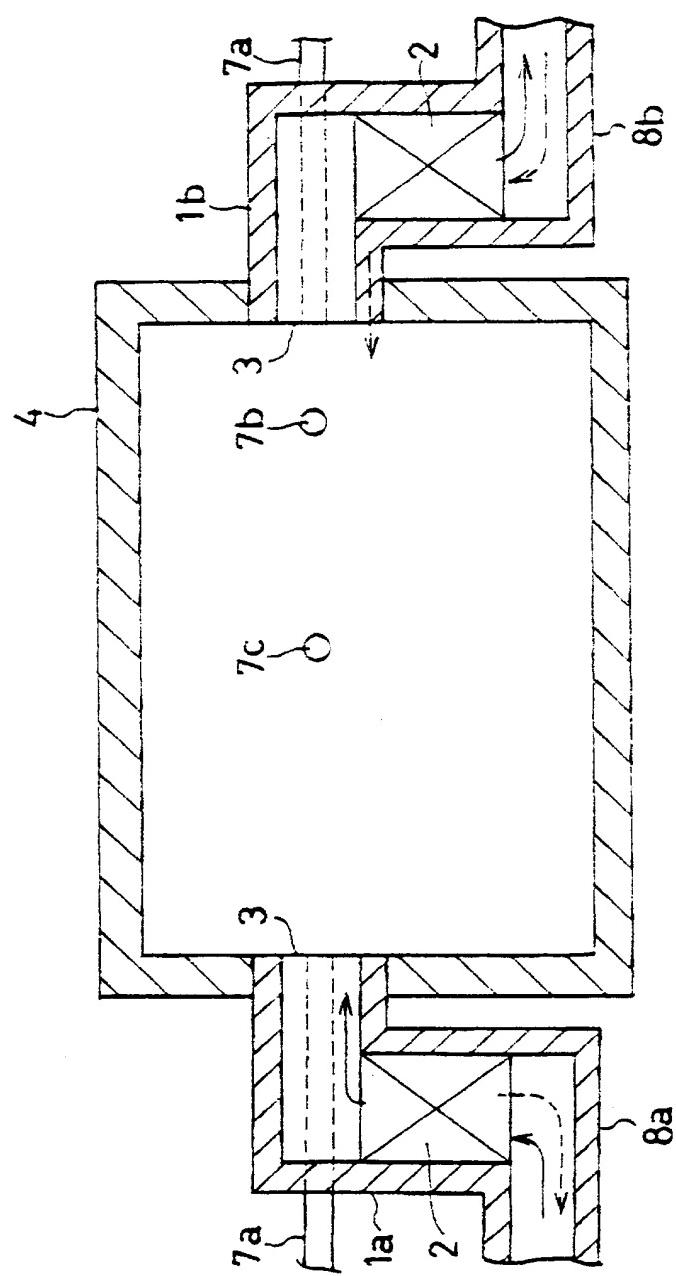


FIG. 3

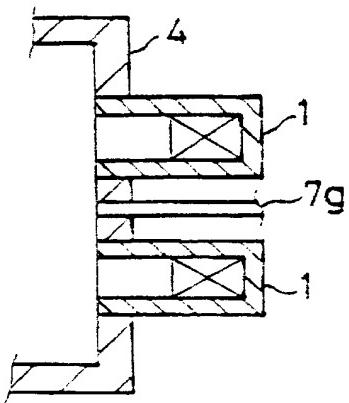
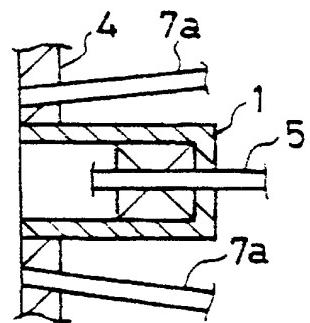


FIG. 4



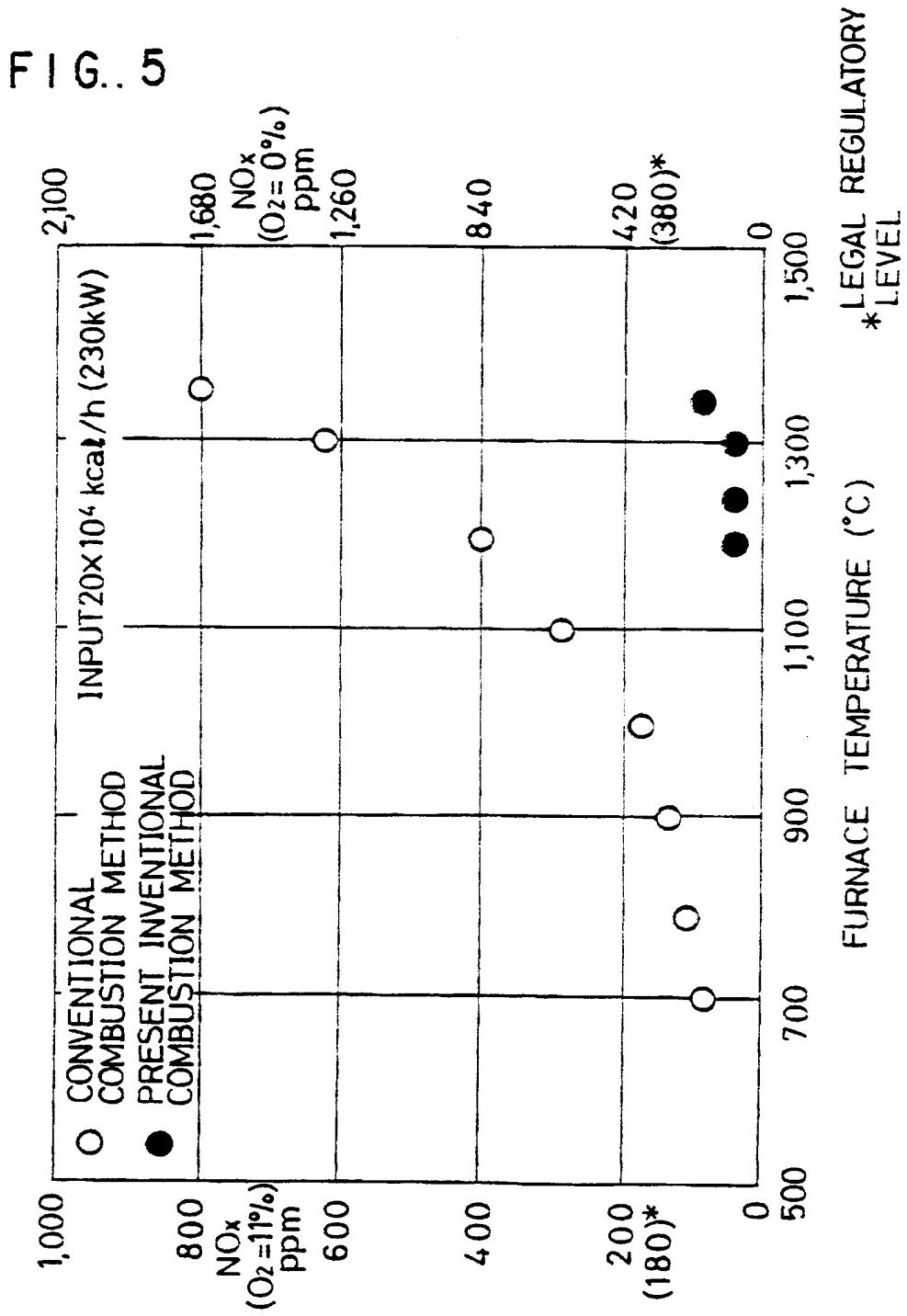


FIG. 6

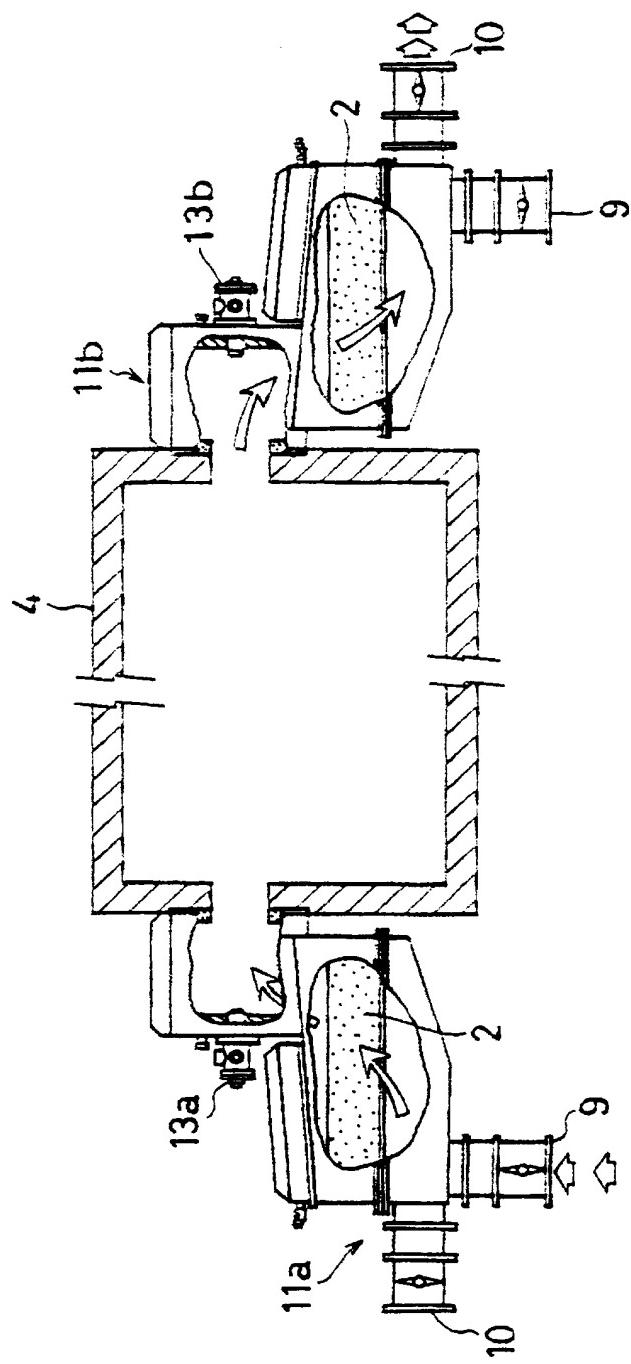


FIG. 7

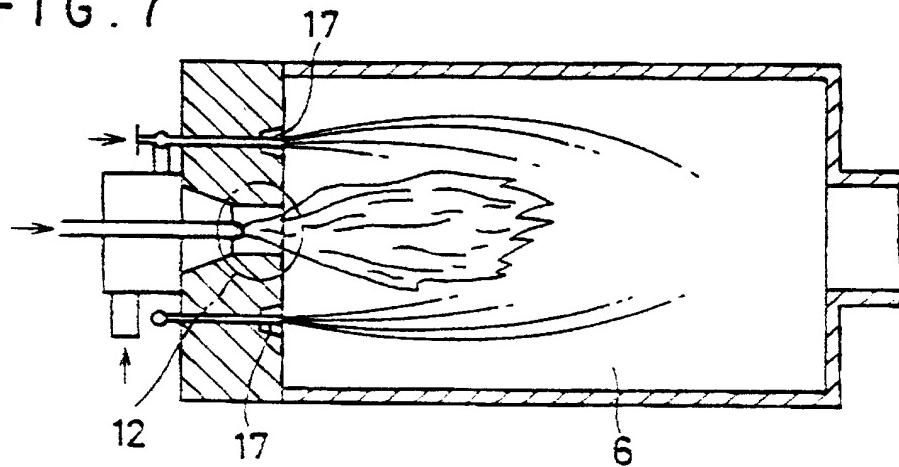
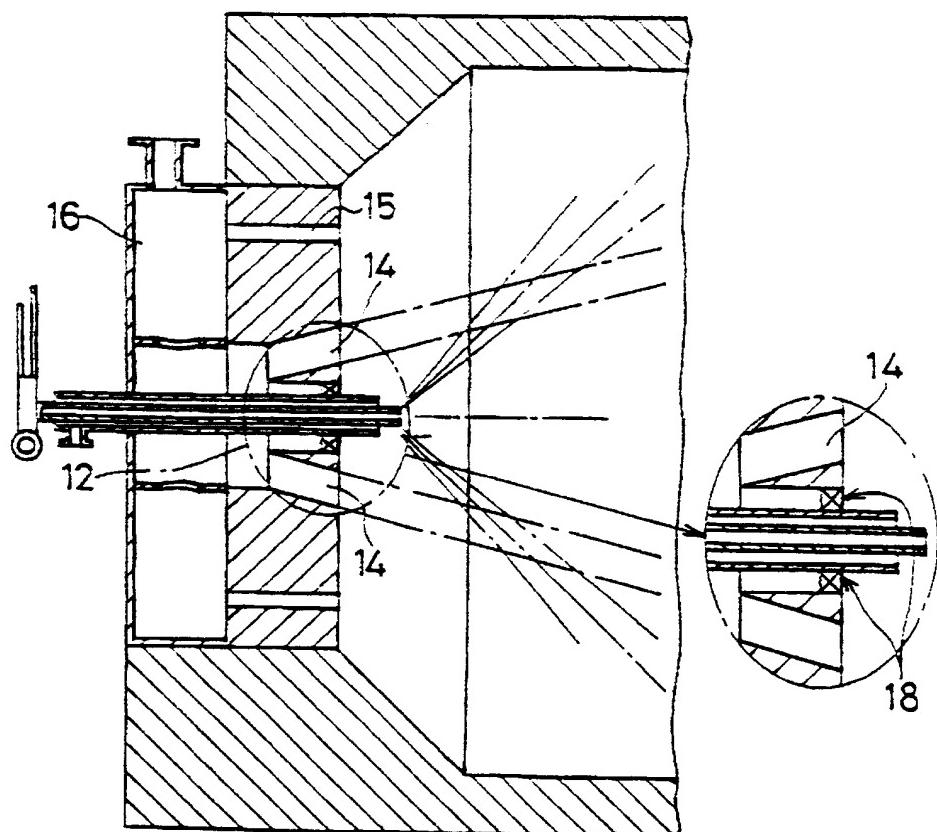


FIG. 8





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 5249

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	PATENT ABSTRACTS OF JAPAN vol. 18 no. 607 (M-1707) ,18 November 1994 & JP-A-06 229509 (TOKYO GAS CO LTD) 16 August 1994, * abstract *---	1,2,5-8, 10,16, 18-20	F23L15/02
X	PATENT ABSTRACTS OF JAPAN vol. 13 no. 434 (M-875) ,28 September 1989 & JP-A-01 167591 (TOKYO GAS CO LTD) 3 July 1989, * abstract *---	1,2,5,9, 10,16,18	
A	---	17	
X	EP-A-0 333 239 (BLOOM ENGINEERING) * column 4, line 54 - column 6, line 26 * * figures 1,2,2A *---	1,2,5-7, 10,16,18	
A	US-A-3 527 445 (STEWART) * column 2, line 53 - column 3, line 18; figure 1 *---	1,2,5,6, 9,13,16, 18	
A	EP-A-0 343 746 (TOKYO GAS CO LTD) * page 2, line 43 - page 3, line 53 * * page 3, line 3 - page 3, line 31 * * figures 1A,1B *-----	22	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F23L F23C F27B C03B
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	12 January 1996	Phoa, Y	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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APPL-DATE: July 27, 1995

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INT-CL (IPC): F23L015/02

EUR-CL (EPC): F23C009/00 , F23L015/02

ABSTRACT:

CHG DATE=19990617 STATUS=O> A low-nitrogen-oxide-producing regenerative burner system for a combustion chamber (4) comprises at least one pair of regenerative preheaters (1a, 1b) for combustion air connected to the combustion chamber to supply preheated air directly thereinto or to

receive combustion products therefrom for heat recovery and at least one fuel supply duct (7) connected to the combustion chamber at a position spaced from the points at which air is delivered to the chamber. The fuel and preheated air are supplied separately to the chamber so that they mix within it and are diluted by combustion products so that the flame temperature is kept low and the production of nitrogen oxides is inhibited. 